IEEE Technology and Society Magazine, March 1985

FEATURE ARTICLE

Computer-Mediated Communication

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Abstract—The use of computers in organizations is discussed in terms of its present and potential roles in facilitating and mediating communication between people. This approach clarifies the impact that computers may have on the operation of organizations and on the individuals comprising them. Communication, which is essential to collaborative activities, must be properly controlled to protect individual and group privacy, which is equally essential. Our present understanding of the human and organizational aspects of controlling communication and access to information lags behind our technical ability to implement the controls that may be needed.

INTRODUCTION

One of the early voices expressing concern over the social impact of computers was that of Alan Westin. [1] To the generalized concern about advancing technology, a common response is that it is useless to try stopping water from running to the sea; instead — it is suggested — in order to prevent damage from erosion and floods, dams and channels should be built to regulate the water flow. With respect to computers and their impact on freedom and privacy, Westin asked: "Who is building the dams?"

It is clear that the most knowledgeable and competent people to do this are the computer professionals themselves. The potential effects of specific characteristics of computer systems on the communities served by them are tremendous. Indeed, computer systems and the communities in which they are embedded are so closely coupled that they must be viewed as components of a single system. Consequently, a computer system cannot be properly designed outside the context of the community to be served any more than its hardware can be properly designed outside the context of its software.

The technological explosion that has taken place in the computer field in recent years has increased by an order of magnitude the potential social impact of computers. This necessitates an updating of my earlier paper on the subject. [2] It is not necessary here to enumerate the detailed characteristics of this explosion. Suffice it to say that the main feature is the advent of the personal computer, all its peripheral equipment, and the local area and long distance communication networks that link together many such computers to large mainframes.

COMPUTER MEDIATED COMMUNICATION

The impact of computers is by now so pervasive, encompassing and diverse that even outlining it would be a major task. All that one can hope to do is to present a point of view for clarifying some of the present and potential effects of computers on the functioning of human organizations and on interpersonal relations. It is helpful for this purpose to distinguish between three major roles that computers are currently playing. These roles are:

- As components of physical systems, most often controlling their operation, as in the case of a space vehicle, a car, or a robot on an assembly line.
- As personal tools used by people in their activities, as in the case of word processors.
- As facilitators of communication between people, most commonly through the collection, storage, processing, and dissemination of information.

While computers may well play more than one of these roles in specific applications, it is still helpful to distinguish among them because their implications are usually quite different.

The primary interest here is the third type of role which is central to what can be called *computer-mediated communication*. This term refers to the process of transferring knowledge between people with the aid of computers. This is just an extension and generalization of the communication processes based on the printing press, telegraphy, telephony, television, and the various associated recording and playback technologies. There are many ways in which computers are currently facilitating or mediating human communication, and more can be envisioned for the future. The following partial list illustrates the scope and significance of the assistance that computers are capable of providing in the future if not at this time.

- Temporary and long-term storage of information with rapid, selective retrieval.
- Compilation of information from different sources and selective distribution and routing to different destinations.

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0278-0097/85/0003-0003$01.00©1985 IEEE

- Means for editing and displaying information to meet individual needs and preferences.
- Content dependent routing of messages; that is, routing to a person whose identity, while unknown to the sender, is implied by the message.
- Personalization of mass communication through automatic selection of information to meet individual needs and interests.
- Management of the context of a conversation. The objective is to minimize misunderstandings between participants by providing to each of them convenient access to relevant information about the other participants, the topic of the conversation, and other matters pertaining to it.
- On-demand transformation of the information being communicated to meet the needs, preferences or interests of individual participants in the communication process. Translation from one language to another is a simple example. Another example is the displaying of an object from a different point of view.
- Storage and dissemination of directly usable knowledge in the form of knowledge-based expert systems. Such a system is MACSYMA [3], which is able to perform a great variety of mathematical manipulations, including symbolic integration, at the level of a competent mathematician.

Capabilities such as context management and translation of point of view, which are still largely in the future, get to the roots of major difficulties that people experience in communicating with one another. People often talk past each other because of different assumed contexts; they also fail to comprehend information because it is presented from an unfamiliar or inappropriate point of view. The ability to capture the knowledge of experts and to make it available to others in a directly usable form is presently the subject of active research. Its potential impact is enormous.

It is very helpful to think of computer activities as components of communication processes between people. It helps one identity missing links and components that may be essential to achieving an intended objective. More importantly, it focuses one's attention on who are the participants in the communication process involving a particular computer activity, and on how the activity affects them individually and collectively in whatever they do and in their interpersonal relations. Finally it helps one understand how the mode of operation of an organization and the people that comprise it may be affected by specific computer activities.

COMMUNICATION, ORGANIZATIONS AND PEOPLE

Communication is essential to the operation of human organizations since information is a basic ingredient of collaborative activities. On the other hand, most people would agree that communication and access to information must be controlled, although the extent of the control and the manner in which it is exercised could be the subject of lengthy debates. There are many reasons for such controls, ranging from the protection of individual privacy to the protection of proprietary information. One compelling pragmatic reason is to avoid information overload. Another one is that providing information about a particular activity is often interpreted as an invitation to participate in it and "too many cooks spoil the broth." Most of these reasons could well be viewed as components of a generalized claim to privacy on the part of individuals, small working groups, and organizations.

It is obvious that claims to privacy on the part of individuals and groups must be continuously balanced against the needs and rights to know on the part of other individuals and groups. Also, the potential benefits that may result from providing access to information must be balanced against the dangers of doing so, with proper attention being given to the posible effects on interpersonal relations. The resulting conflicts are often resolved on an ad-hoc basis, and occasionally by looking the other way and pretending that what actually takes place is consistent with official organization charts and policies.

The reason for bringing up these points is that computer communication networks are slowly but surely on their way to becoming the nervous systems of human organizations. As more significant communication takes place through them, it will become more important to control such communication in a proper and dependable manner. The first, major problem to be faced is that the desired controls and the procedures to be followed in case of conflicts will have to be clearly stated in order to be embodied in computer programs, even if human intervention is contemplated. On the other hand, organizations are usually reluctant to be explicit about such matters, and probably for good reasons. Unfortunately, computers tend to force people's hands with respect to information; they may provide information of which one prefers to be officially unaware, and they may preclude the possiblility of claiming that information that had better be forgotten cannot be found. Similar communication control problems exist also at the interfaces between business organizations and between sovereign nations.

The reason why we have difficulties with all such problems is that we lack an appropriate conceptual framework for dealing with information. We do not know how to deal with it as a commodity, and we do not know much about how collaborative activities are affected by different communication patterns, and how communication influences people's attitudes and interpersonal relations. I am not aware of work on such questions commensurate in intensity to what I believe is their urgency.

THE TECHNOLOGY OF COMMUNICATION AND INFORMATION CONTROL

The technical means for controlling communication and access to stored information are by now in better shape than our knowledge about how to utilize them. But there are still major problems to be solved. There is now a reasonable choice of computer systems with the necessary access control features; this was not the case a decade ago. However, experience indicates that while such control mechanisms work as intended under normal circumstances, they can usually be circumvented by persistent, knowledgeable programmers, such as high school students bent on sharpening their computer skills.

One reason for these operational problems is that computer systems are so complex that it is impossible to verify that they behave precisely in the intended manner. A single programming error which does not affect normal operation may provide an entry way to an intruder. Many such errors are identified and corrected over time, but one is never sure that all of them have been eliminated. Another reason is lax operating and maintenance procedures. Careless operation may allow intruders to walk into a system through the front door, and systems programmers, without proper supervision, may introduce new errors while eliminating old ones or while installing new system features. There is also the possibility of a systems programmer constructing a convenient door into a system for the benefit of others. Such dangers can be significantly reduced by careful system auditing, but only at a correspondingly significant cost.

The availability of relatively inexpensive yet powerful personal computers has provided individuals with a very dependable way of controlling communication with others. They can store locally, e.g., on a diskette, information they do not wish to share; they can disconnect their personal computer from whatever network it is normally connected to, and they can avoid using programs that may have been modified without their knowledge. They can do all this while preserving the ability to use their computer as a personal working tool, and of reconnecting it to a network when they wish to communicate with others and are ready to do so. This ability to isolate oneself while retaining the ability to share information and communicate with others at the appropriate time, is close to an operational definition of the concept of privacy. Fortunately, the economics of computation are most likely to favor more and more the use of interconnected personal computers over the sharing of large mainframe computers, with the latter being relegated to managing common mass-storage devices and to performing major computational tasks. In other words, the trend is clearly in the direction of giving individuals greater control over computation and communication, a most desirable trend that could hardly have been envisioned a decade ago.

Another recent technological development of considerable importance is the invention of double-key enciphering schemes, in which one key is used for enciphering and the other for deciphering [4]. The operation of these schemes is based on the fact that pairs of related keys can be readily constructed such that neither key can be derived from the other. More precisely, no one knows, *at this time*, how to compute either key from the other in a useful time span. The usefulness of such schemes lies in the fact that one key can safely be made public while holding the other one secret. Then, any information enciphered with the publicly known key can be deciphered only by a person knowing the secret key. Conversely, any message enciphered with a secret key, while decipherable by any interested party, can be trusted to have originated from the person in possession of the secret key corresponding to the one used in deciphering it. In other words, such enciphering schemes can be used both to authenticate the identity of the originator of a message, and to ensure that a message can be deciphered only by the person for whom it is intended, without ever having to distribute secret keys.

There are stil major technical problems that need prompt attention. A very important one is that of maintaining intellectual control over programs of ever-increasing complexity, lest we end up being controlled by them. Tales are often told of computerized robots eventually taking over the world by evolving into a new species of intelligence far superior to that of mankind. I cannot get excited about such a possibility, but I am seriously concerned about a different way in which computers may "take over" from us. This is our growing dependence on computer systems and application programs of such complexity that no one fully understands their behavior. Of particular concern are programs on which we may depend in the future for information and advice pertaining to our activities. If we do not know what factual information and what assumptions are built into such programs, or if we do not understand how they are utilized in reaching the conclusions presented to us, we are in effect at their mercy; or, more precisely, at the mercy of their developers.

The fact of the matter is that we already depend on the advice and help of many people: doctors, lawyers and other experts. If we are wise, we get references. More importantly, we ask questions before acting on their advice to make sure that it is based on sound facts and arguments. We can conceive of doing the same thing with expert programs. As a matter of fact, there exist experimental programs that can answer questions about how they have reached some particular conclusion. This is only a beginning, but it gives me some confidence that we may eventually learn how to write programs capable of explaining their own behavior to our satisfaction. This would be a reasonable solution to the problem of maintaining intellectual control over them.

SUMMARY AND CONCLUSIONS

This paper presents a way of looking at the impact of computers on human organizations and on the people that comprise them to help clarify what is happening today and what may happen in the future. The main points of emphasis are:

- Computers can play a major role in human organizations and in the whole society by facilitating communication and mediating the transfer of knowledge between people. There are many ways in which computers can help human communication, although most of them are still on the drawing board.

- Looking at computer activities as components of communication processes between people helps one to identify the actual participants and to understand the present and potential impact on them.
- Communication and information-sharing are essential to the functioning of human organization, but they must be controlled in a dependable manner to protect individual and group privacy, which is also essential.
- Controlling communication and access to information in computer systems requires explicit policies and procedures in an area where ambiguity is commonly used to cope with unresolved conflicts.
- Our understanding of how to formulate policies and procedures about information lags behind our knowledge about protecting information in computer systems.
- The availability of personal computers and the development of double-key enciphering schemes are making it possible for individuals and groups to benefit from the use of computers without compromising their own privacy.
- A major problem on which we must focus our attention is that of developing programs that can explain their own behavior in sufficient detail to warrant our trust.

Formerly, the impact of computers on privacy and on the balance of power between organizations and individuals was of major concern largely because of the total control that organizations exercised over computers. The availability of powerful yet relatively inexpensive personal computers has radically changed the situation.

It is now possible to be much more optimistic about the future impact of computers than it was a decade ago. Computer technology seems to be progressing in the right direction, and the problems arising from ever-increasing software complexity do not now seem insurmountable.

ACKNOWLEDGMENTS

I wish to thank F. J. Corbato for many helpful editorial suggestions. I am grateful to him, above all, for sharing with me his deep understanding of computer systems during two decades of professional association and personal friendship. I am grateful also to J. H. Saltzer to whom I periodically turn for authoritative information on the technology of computer security and access control.

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